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A REVISION OF THE NEARCTIC GENERA OF ELMIDAE (Coleoptera)

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(Continued from October issue)

Hexacylloepus Hinton

Genotype: *Elmis smithi* Grouvelle. Grenada. Subsequent designation.

Nearly 20 species of *Hexacylloepus* have been recorded as occurring only in the New World of which one species, *ferrugineus* Horn, was described from Texas. This is the only North American genus of Elmidae whose larva has not been discovered. However, because of the close relationship of the adult to the more primitive group of genera, the larva probably has a posterior sternum, the mesopleuron and metapleuron each may be of 2 parts, and the first 7 abdominal segments probably will have pleura. *H. ferrugineus* is somewhat like *Ordobrevia* in general appearance but has a distinct patch of tomentum on the tibia. Hinton (1940) considered *Hexacylloepus* as not being closely related to *Cylloepus* but distinguished it on external characters by its complete transverse band of tomentum on the prothoracic hypomeron. *H. ferrugineus* is smaller than *Cylloepus abnormis* Horn measuring 2 mm. whereas the latter is 3.5 mm. In addition to the hypomeral differences described, the elytron of *H. ferrugineus* has 7 complete rows of punctures, the rows laterad of the seventh being indistinct. An undescribed Southwestern *Cylloepus* has 9 distinct rows of punctures.

Cylloepus Erichson

Genotype: *Limnius araneolus* Müller. Peru. Subsequent designation.

Only one of the more than 50 species described in *Cylloepus,* found only in the New World, is known to occur in the United States. This is *Elmis abnormis* Horn from Arizona which restudy has shown to belong to this genus. The adult closely resembles species of the genus *Stenelmis* but has a distinct patch of tibial tomentum as in fig. 6, and the last sternite is conspicuously produced on each side margin near the apex. *Stenelmis* has no tibial tomentum, and the lateral margin of the last sternite is without large angulations. Larvae of *Cylloepus* have not been studied and their characterization is taken from Hinton (1940). The prothoracic pleura (fig. 37) are undivided, meeting on the middle line of the venter. This would appear to be unique among related North American genera in which there is a distinct undivided posterior sternum behind the coxae, as in fig. 34. The mesopleuron and metapleuron are each of 1 part, another distinctive feature in this section of the family. The first 8 abdominal segments possess pleura, the pleuron of the eighth segment being parallel sided, the margins well separated all the way to the posterior margin of the sternite. The last abdominal segment (fig.

38) has two acute points at apex. The complete enclosure of the prothoracic coxal cavities by the pleura is considered fundamentally closely relating *Cylloepus* to *Stenelmis* and allies.

Macronychus Müller

Genotype: *Macronychus quadrituberculatus* Müller. Europe. Monobasic.

In addition to the eastern North American *glabratus,* two Old World species are known, all revised by Hinton (1940b). Larvae of the European *quadrituberculatus* have 7 abdominal pleura instead of 6 as in *glabratus.* Otherwise the adults and larvae of the two species appear closely similar. The larva of *glabratus* was previously illustrated by West (1929a, p. 722, fig. 8) as a *Stenelmis.*

Zaitzevia Champion

Genotype: *Zaitzevia solidicornis* Champion. India. Original designation.

Our species, all western, have short antennae similar to those of *Macronychus* but there are 8 instead of 7 segments. Indian representatives have not been available for study but North American individuals agree well with the generic description. I have examined an unassociated larva from Japan that appears to be congeneric with North American larvae of *Zaitzevia.*

Heterlimnius Hinton

Genotype: *Helmis ƙoebelei* Martin. Subsequent designation.

This genus was described to include the bulk of the North American species of Elmidae still remaining in *Elmis* after various species had been removed previously by Hinton to other genera. However, the larvae of *ƙoebelei* and *corpulentus* LeConte each has the metathoracic and mesothoracic pleuron divided into 2 parts, whereas larvae of many of the remaining species have a single pleurite. The prosternum (fig. 65) has three parts adjoining the lateral suture. The genus *Ceralimnius* was indicated by Hinton (1939-143) in the legend for a prosternal drawing of *corpulentus* LeConte but was unaccompanied by a description. This is the only North American elmid with a 10-segmented antenna. This is now believed to be a specific characteristic only, and the genus, if valid, should be suppressed as a synonym of *Heterlimnius. Heterlimnius* adults are closely similar in general appearance to those of *Optioservus* and are rather unsatisfactorily distinguished by their more deeply impressed elytral striae. *H. ƙoebelei* will trace to *Optioservus* in the key to adult genera but it is my belief that its larval characteristics indicate its phyletic affinity with *corpulentus.*

Limnius Erichson

Genotype: *Elmis tuberculatus* Müller. Europe. Subsequent designation.

This is one of the few European genera which is represented in the New World, our only representatives being one or two very small species occurring in the Appalachian region. They are about 1 mm. in length and are otherwise distinctive by the smooth pronotum having a complete carina on each side extending from the posterior to the anterior margin. The maxillary palpus is 3-segmented, a feature characteristic of only 3 other North American genera. Only two larvae believed to be *Liminus* have been examined. These larvae are closely simialr to those of the western *Heterlimnius,* having the

same basic thoracic and abdominal arrangement of sclerites, and are distinguished from *Heterlimnius* by their smaller size and eastern distribution. It is a surprising situation in this family to find the larvae of two genera so closely alike structurally when the adults represent different phyletic units.

Narpus Casey

Genotype: *Narpus angustus* Casey. Monobasic.

West (1929) has illustrated a larva that appears to be a representative of this genus. The larva is large but slender and has two broad transverse smooth areas. (fig. 61) on the pronotum. The postpleurite (fig. 58) has 1 part. The adult of *Narpus* is conspicuous among western genera for its large size and by having the pronotum evenly punctured and without lateral carinae. In this feature it is similar to *Dubiraphia* but the latter genus has much smaller representatives.

Ampumixis new genus

Genotype: *Elmis dispar* Fall.

Adult. Antenna 11-segmented, slender. Maxillary palpus 3-segmented. Pronotum (fig. 23) with flat median longitudinal ridge or slight excavation extending from base nearly to anterior margin of pronotum; side of pronotum with a longitudinal carina extending from base nearly to anterior margin; area between carina and lateral margin in basal half strongly convex, the area in anterior half concave, the entire area strongly punctured, contrasting sharply with nearly smooth area between lateral carinae. Prosternum (fig. 22) short before coxae and with parallel ridges extending from coxae to anterior margin. Elytron strongly convex with 9 nearly complete strongly impressed rows of punctures; outer margin evenly convex before apex. Metasternum very short with a complete carina extending from middle coxa to posterior coxa, the distance between these coxae approximately equal to the longitudinal diameter of the middle coxa. First abdominal sternite very short at bottom of coxal groove, carinate on each side from bottom of groove to posterior margin; 4th sternite produced at each posterior angle; last sternite nearly straight on sides, truncate at apex. Each tibia with a fringe of tomentum in apical half; tarsal claw without basal tooth.

Larva. Body triangular in cross section. Prosternal region without a posterior sternum, the anterior sternum and prepleurite fused and reaching lateral margin; postpleurite of 1 part. Mesopleuron and metapleuron each of 2 parts. First 7 abdominal segments each with a pleuron. Pronotum with a large swelling between meson and lateral margin in basal region, somewhat as in fig. 68, and another adjacent to anterior margin, the area between lateral swellings broadly transversely grooved. Mesonotum and metanotum each with a large basal swelling on each side. First 8 abdominal tergites (fig. 69) each rather strongly tuberculate on meson at posterior margin and between meson and spiracle near lateral margin, each swelling with a dense group of scales. Last segment (fig. 71) triangular in cross section, the apex very shallowly emarginate and without lateral apical spines. Operculum strongly narrowed behind, narrowly rounded at apex.

The only known species of the genus, *dispar* Fall, has until recently been known only from the type male and a supposedly dimorphic female.

Study of adults and associated larvae from the type locality and elsewhere in California clearly shows *dispar* to be distinctive generically from *Elmis* and other North American Elmidae. The adult is similar to and closely related to *Cleptelmis* but may be distinguished by characters indicated in the keys. The larva resembles the eastern *Promoresia*.

Cleptelmis new genus

Genotype: *Elmis ornata* Schaeffer.

Adult. Antenna 11-segmented, slender. Maxillary palpus 3-segmented; head with a dense patch of tomentum below each eye. Pronotum (fig. 25) wider than long, evenly convex on median portion, each side with a long carina extending from basal margin to anterior margin; basal ⅓ of carina curved mesally then straight to base; long carina nearly joined on side in basal ⅓ by a short curved ridge extending from basal margin; entire surface with small rugose punctures. Prosternum moderately long in front of coxae with slightly divergent ridges extending from inner margins of coxae nearly to anterior margin. Elytron with 9 complete rows of punctures; outer margin of elytron evenly convex before apex. Metasternum distinctly longer than longitudinal width of middle coxa, each side with a carina arising on inner margin adjacent to coxa, the two carinae diverging and nearly attaining posterior margin. First abdominal sternite short at bottom of coxal groove with a carina on each side reaching posterior margin of sternite; fourth sternite not produced at posterior angles; last evenly rounded on lateral margins to the roundedly angulate apex. Each tibia with a fringe of tomentum in apical ½ to 4/5.

Larva. Body cylindrical. Prosternal region without a posterior sternum; anterior sternum and prepleurite fused and reaching lateral margin; postpleurite of 1 part. Each mesothoracic and metathoracic pleuron of 2 parts. First 7 abdominal segments with pleura. Pronotum obliquely depressed from lateral margin to a point near meson. Remainder of body segments nearly evenly convex. Last segment with shallow apical emargination unproduced on either side. Operculum similar to that described for *Ampumixis*.

Hinton (1935) believed *addenda* Fall and *ornata* Schaeffer to be North American representatives of *Elmis*. However, larvae of the European genotype, *Elmis maugei* Bedel, differ by having the thoracic and abdominal margins strongly expanded somewhat like that of *Phanocerus*. Larvae of *addenda* and *ornata* agree with *Elmis* in the ventral thoracic arrangement of sclerites, but only *addenda* has 6 abdominal pleura as in *maugei*. *C. ornata* has 7 pleura. Adults of *maugei* have the lateral pronotal carina complete and evenly curved or nearly straight, not angled as in *Cleptelmis*, and there is no curved ridge on the outside of the carina near base in *maugei*.

Dubiraphai new genus

Genotype: *Elmis quadrionata* Say

Adult. Antenna 11-segmented, slender. Maxillary palpus 4-segmented. Head with a large continuous patch of flat tomentum behind and below each eye. Pronotm (fig. 26) evenly punctured and convex above, without carinae or other irregularities. Prosternum (fig. 29) with short diagonal carinae

which do not reach anterior margin. Elytron without carinae and having 9 rows of punctures. Metasternum with a carina arising on inner margin of middle coxal cavity and extending posteriorly at a slight diagonal for 2/3 length of metasternum behind middle coxa. First abdominal sternite short at bottom of coxal groove and with a very faint abbreviated carina; fourth sternite not produced at posterior angles; last sternite straight on lateral margins, rounded at apex. Tibiae with tomentose patches; tarsal claw without basal tooth.

Larva. Body slender, convex (fig. 53). Prosternal region without a posterior sternum, the fused anterior sternum and prepleurite reaching lateral margin; postpleurite of 1 part. Each mesothoracic and metathoracic pleuron of 2 parts; first 8 abdominal segments with pleura. Pronotum and remainder of thoracic and first 8 abdominal tergites evenly convex. Last abdominal segment (fig. 54) unusually long, about 4 times longer than wide, nearly truncate at apex and with two long apical spines. Operculum (fig. 55) about 1/3 length of last segment and with an acute apical spine.

Hinton (1936) recharacterized the Australian genus *Simsonia* Carter and Zeck (1929, 58) to include the North American *Elmis vittata* Melsheimer, *Elmis bivittata* LeConte, *Elmis quadrinotata* Say, *Helmis brunnescans* Fall, and *Helmis dietrichi* Musgrave. *Australian* representatives of *Simsonia* have not been available for study but the adult transverse pronotal impressions and the "claws, especially the posterior with an enlargement (sublobate) at base" are features described for *Simsonia* which do not apply to North American species. Comparison with the prosternal illustrations given by Carter and Zeck for several Australian species of *Simsonia* shows that in our species the prosternum between the coxae is broader, and the prosternal carinae are much more sharply diverging. Larvae of Australian *Simsonia* have not been examined but I believe the adult differences given indicate the American species to be generically distinct from *Simsonia.*

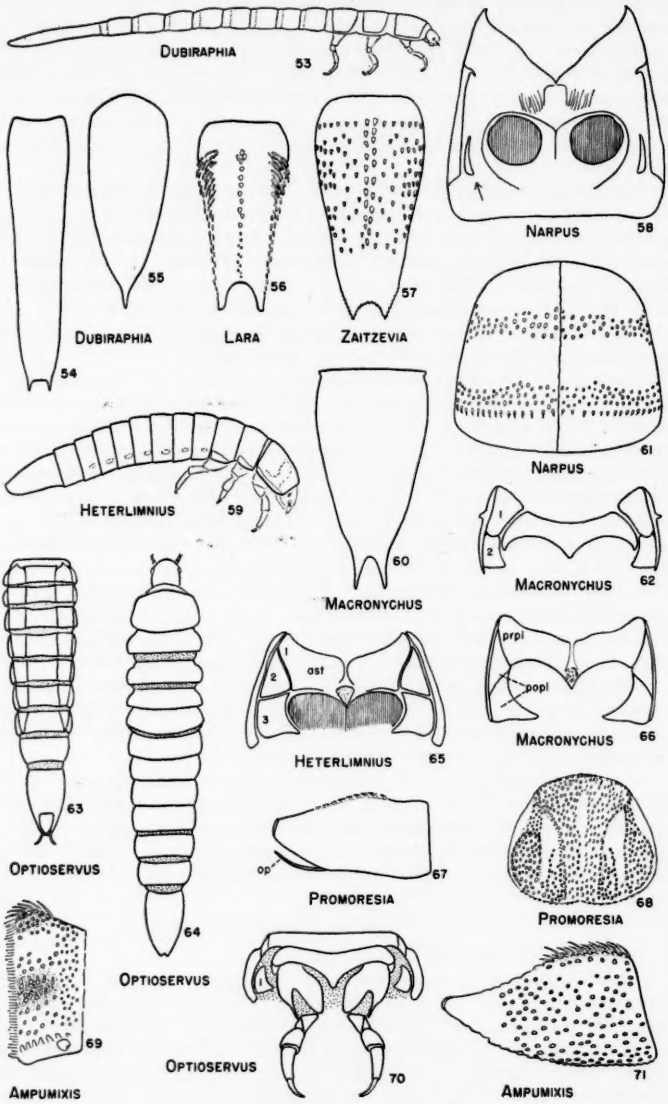
The larva of *Dubiraphia* (fig. 53) is a very elongate, pale and soft bodied creature in which it is difficult to observe clearly, in every individual, the ventral thoracic structure. It was illustrated as the genus *Ancyronyx* by Böving and Craighead, and *Simsonia* by Peterson.

Dubiraphia includes the first four species listed by Hinton in *Simsonia,* and *H. dietrichi* has been removed to the new genus *Gonielmis* under which its differences from *Dubiraphia* are fully discussed. *Dubiraphia* adults are similar to *Narpus* having the pronotum evenly punctured and convex and without lateral carinae, but *Narpus* has a 3-segmented maxillary palpus instead of 4.

Gonielmis new genus

Genotype: *Helmis dietrichi* Musgrave

Adult. Antenna 11-segmented, slender. Maxillary palpus 4-segmented. Head with a broad tomentose area behind and below each eye. Pronotum (fig. 28) evenly convex, generally evenly punctured, the punctures a little more scabrous in a slight depression at basal margin between meson and lateral margin, surface of pronotum without carinae or other irregularities. Prosternum (fig. 32) strongly narrowed between coxae; without carinae. Elytron with 10 rows of punctures, none abbreviated at base near scutellum;


DUBIRAPHIA
53
NARPUS
58
54
55
DUBIRAPHIA
56
LARA
57
ZAITZEVIA
61
NARPUS
HETERLIMNIUS
59
60
MACRONYCHUS
1
2
MACRONYCHUS
62
63
OPTIOSERVUS
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OPTIOSERVUS
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HETERLIMNIUS
65
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MACRONYCHUS
66
op
67
PROMORESIA
68
PROMORESIA
69
AMPUMIXIS
OPTIOSERVUS
70
71
AMPUMIXIS

lateral margin before apex evenly rounded, slightly serrate. Metasternum on side about 1½ times longer than median length of middle coxa; carinae absent. First abdominal sternite without carinae; fourth sternite produced at posterior angles; last sternite slightly convex on lateral margins and evenly rounded a apex. Tibiae with fringes of tomentum; tarsal claw without basal tooth.

Larva. Body triangular in cross section, the lateral margins not expanded. Prosternal region without a posterior sternum; postpleurite of 2 parts so that 3 prothoracic pleurites reach the lateral suture, as in fig. 65. Mesopleuron and metapleuron each of 2 parts, somewhat as in fig. 62, the anterior part long and narrow, about ½ or less width of posterior part. First 7 abdominal segments with pleura. Dorsum nearly evenly covered with rounded tubercles with a slight tendency for some on the abdomen to become arranged into longitudinal rows; pronotum transversely impressed in apical 2/5 between meson and lateral margin; basal region near meson with an irregular longitudinal dark brown mark lying in a slight depression. Mesonotum and metanotum each with a longitudinal brown mark, enlarged at apex, lying half way between meson and lateral margin; area laterad of each mark slightly convex. First 8 abdominal segments with tergites each moderately tumid on meson in apical 2/3, each tumidity covered with a group of scale-like hairs as in fig. 69; segment evenly convex from meson to lateral margin. Last segment strongly ridged, the ridge finely serrate; apex of segment shallowly emarginate, not produced on sides. Operculum nearly parallel in basal ½, the sides strongly convergent and straight to the acute apex.

The only species known in this genus was originally associated by Musgrave with those species now placed in *Dubiraphia* based on its non-carinate adult pronotum. However, the pronotum has a faint group of punctures adjacent to the posterior margin between the meson and the lateral angle in the

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PLATE IV, LARVAE OF ELMIDAE

Fig. 53. Dubiraphia sp. Lateral view.
Fig. 54. Dubiraphia sp. Dorsal view of last abdominal segment.
Fig. 55. Dubiraphia sp. Operculum.
Fig. 56. Lara sp. Dorsal view of last abdominal segment.
Fig. 57. Zaitzevia sp. Dorsal view of last abdominal segment.
Fig. 58. Narpus sp. Prosternum.
Fig. 59. Heterlimnius sp. Lateral view.
Fig. 60. Macronychus glabratus Say. Dorsal view of last abdominal segment.
Fig. 61. Narpus sp. Pronotum.
Fig. 62. Macronychus glabratus Say. Mesosternum, pleural parts numbered.
Fig. 63. Optioservus sp. Ventral view of abdomen showing 7 lateral pleura.
Fig. 64. Optioservus sp. Dorsal view of larva.
Fig. 65. Heterlimnius sp. Prosternum, pleural parts numbered (ast=anterior sternum).
Fig. 66. Macronychus glabratus Say. Prosternum (prpl=prepleurite, popl=2 parts of postpleurite).
Fig. 67. Promoresia tardella Fall. Lateral view of last abdominal segment (op=operculum).
Fig. 68. Promoresia tardella Fall. Pronotum.
Fig. 69. Ampumixis dispar Fall. Lateral view of fourth abdominal segment.
Fig. 70. Optioservus sp. Mesosternum showing 1 pleural part.
Fig. 71. Ampumixis dispar Fall. Lateral view of last abdominal segment.

same position as the base of the lateral carina found in other genera. There is no such group of punctures in *Dubiraphia*. This characteristic, though faint, appears to indicate a closer affinity with *Promoresia* and *Optioservus* in which there is a distinct lateral carina. In general appearance *Gonielmis* is much like *Promoresia elegans* LeConte having the same type of diagonal elytral markings (fig. 30). However, in *elegans* there is a distinct basal pronotal carina between the meson and lateral margin.

The larva of *Gonielmis* is somewhat similar to that of *Promoresia* having the abdominal tergites at middle slightly tumid but not convex on sides as in *Promoresia*. Fundamentally it appears to be nearer *Heterlimnius* (fig. 59) and *Limnius* from both of which it is distinguished by the very narrow anterior pleurite in each mesopleuron and metapleuron. The non-tumid abdominal tergites will further distinguish *Heterlimnius* and *Limnius*. *Gonielmis* appears to be unique among North Amercan elmid larvae by having two longitudinal dark marks on each thoracic tergite.

Optioservus new genus

Genotype: *Limnius trivittatus* Brown

Adult. Antenna 11-segmented, slender. Maxillary palpus 4-segmented. Head with a large continuous patch of tomentum behind and below each eye. Pronotum (fig. 33) wider than long, evenly convex and punctured, and with a short carina in about basal ¼ or ⅓ between meson and lateral margin. Prosternum broad but distinctly narrowed between coxae, with two divergent carinae or ridges which do not reach anterior margin. Elytron with 10 rows of punctures, none near suture abbreviated; outer margin at most slightly emarginate before apex and very finely serrate. Metasternum about 1½ times longer on side than longitudinal width of middle coxa and without carinae. First abdominal sternite (fig. 30) with a very vague carina on each side of median lobe which does not extend to posterior margin; fourth sternite produced at each posterior angle, the produced portion together with marginal expansions of the 2nd and 3rd sternites embracing the elytral epipleuron; last sternite evenly convex on lateral and apical margins. Tibia fringed with tomentum; tarsal claw without basal tooth.

Larva. Body triangular in cross section. Prosternal region without a posterior sternum, the anterior sternum and pleurite fused and reaching lateral margin; postpleurite of 2 parts. Each mesothoracic and metathoracic pleuron (fig. 70) of 1 part. First 7 abdominal segments (fig. 63) with pleura. Pronotum with a transverse depression on each side in apical ½, and a longitudinal depression near lateral margin. Mesonotum and metanotum each broadly depressed near lateral margin. Abdominal segments slightly triangular in outline, the dorsal surface (fig. 64) without large conspicuous swellings; last segment slightly emarginate at apex and without lateral projections. Operculum as in fig. 63.

With *Heterlimnius* restricted to include its genotype *Elmis koebelei* Martin and one or two additional western species, and with *Elmis tardellus* Fall, *Limnius elegans* LeConte, and *Limnius subarcticus* Brown removed to *Promoresia*, there remains 5 names in Hinton's list of species in *Heterlimnius* without generic placement. To these I would add 6 others which have re-

mained in *Elmis* (=*Helmis*) or *Limnius* until the present. I have selected *trivittatus* Brown as the genotype of *Optioservus* because of its distinctive coloration together with its small size, the adult having 3 longitudinal elytral reddish stripes, and the length not exceeding 2 mm. Some other and older species are more variable in size, body shape and color, and it cannot be stated at this time what are the limits of species variation in the genus. It appears probable, however, that the genus will prove with careful study, especially features of the genitalia, to be considerably larger in numbers of species than my list would suggest.

This genus and *Microcylloepus* have the widest distribution of any in North America, representatives having come from most parts of the United States. Curiously no species of *Optioservus* are known to occur in Mexico.

Adults of this genus appear closely related to *Heterlimnius* and *Promoresia,* and were it not for the distinctive features of the larvae of these three genera I would have retained all in *Heterlimnius.* The western *Heterlimnius koebelei* with an 11-segmented antenna keys to *Optioservus,* and for its distinguishing features see the discussion under *Heterlimnius.* From *Promoresia* the adults of *Optioservus* are distinguished primarily by the toothed or serrate lateral and posterior prothoracic margins. Larvae of *Optioservus* are very similar in general appearance to those of *Heterlimnius* (fig. 59) but have 1 instead of 2 parts to the mesopleuron and metapleuron. The abdominal tergites of *Optioservus* have nearly even surfaces and are without median humps and lateral swellings as in *Promoresia.*

Promoresia new genus

Genotype: *Elmis tardellus* Fall

Adult. Antenna 11-segmented, slender. Maxillary palpus 4-segmented. Head with tomentose patch below each eye. Pronotum (fig. 27) nearly evenly convex, coarsely punctured on sides and basal region, each side between meson and lateral margin with a longitudinal carina in about basal 1/3. Prosternum rather strongly narrowed between coxae and with short diverging ridges not reaching anterior margin. Elytron with 10 rows of punctures, the last three with punctures confused in basal region; second row complete; elytral margin straight or faintly rounded before rounded apex. Metasternum 1½ times longer than median length of middle coxa and without carinae. First abdominal sternite short between base of coxal groove and posterior margin; 4th sternite produced at posterior angles as in fig. 30; last sternite evenly rounded on sides. Each tibia with fringe of hairy tomentum in apical half; tarsal claw without basal tooth. Sides of thorax and abdomen with flat tomentum.

Larva. Nearly triangular in cross section. Prosternal region without a posterior sternum, the anterior sternum and prepleurite fused and reaching lateral margin; postpleurite of 2 parts. Each mesothoracic and metathoracic pleuron of 1 part. First 7 abdominal segments with pleura. Pronotum (fig. 68) with a wide shallow depression on meson in anterior half, and a large basal swelling before posterior margin on each side of meson, the area before each swelling with a wide curved depression. Mesonotum and metanotum each with a large swelling near lateral margin. First 8 abdominal tergites each with a large angular swelling on meson at posterior margin, similar to

fig. 69 but more pronounced, and a smaller rounded swelling between meson and lateral margin of each tergite; last segment strongly ridged on meson, the apex of segment very shallowly emarginate and not angulately produced on each side. Operculum acute at apex.

This genus also includes *Limnius elegans* LeConte and *Limnius subarcticus* Brown whose larvae have not been definitely associated. However, the adults of *tardella* and *elegans* are so closely similar that the larva of *elegans* when discovered will probably be much like that of *tardella*. *Promoresia* adults are closely related to *Optioservus* and may be distinguished chiefly by their untoothed or unserrated lateral and posterior prothoracic margins. *P. tardella* and *elegans* adults are generally narrower in form than *Optioservus*. Larvae of the two genera are similar in number and arrangement of the thoracic and abdominal pleura but *Promoresia* larvae are conspicuously different by their angulate mesal and very convex lateral tubercles somewhat as in fig. 69. West's illustration of the larva of *Elmis quadrinotata* Say (1929, p. 722) appears to be a *Promoresia*.

List of Nearctic species of Elmidae

Phanocerus Sharp (1882-128)
- clavicornis Sharp (1882-129) Tex. Mex. C.A.

Lara LeConte (1852-42)
- avara LeConte (1852-42) W.
- avara amplipennis Darlington (1929-330) W.
- gehringi Darlington (1929-329) W.

Ancyronyx Erichson (1847-522)
- variegatus Germar (1824-89) Macronychus E.
  - *cinctus* Say (1825-186) Elmis E.

Ordobrevia Sanderson
- nubifera Fall (1901-238) Stenelmis W.

Stenelmis Dufour (1835-158)
- antennalis Sanderson (1938-695) SE.
- beameri Sanderson (1938-671) Mo. Ark.
- bicarinata LeConte (1852-44) E. SW.
- crenata Say (1825-21) Elmis E.
  - *sordida* Motschulsky (1859-51)
- concinna Sanderson (1938-674) E.
- convexula Sanderson (1938-704) Fla.
- calida Chandler (1949-133) Nev.
- calida moapa La Rivers (1949-218) Nev.
- douglasensis Sanderson (1938-685) Mich.
- decorata Sanderson (1938-701) E.
- exigua Sanderson (1938-669) Ark.
- exilis Sanderson (1938-680) Ark.
- fuscata Blatchley (1925-164) Fla.
- grossa Sanderson (1938-686) S.
- hungerfordi Sanderson (1938-690) Fla.
- humerosa Motschulsky (1859-50) E.
  - *linearis* Zimmerman (1869-259)
- knobeli Sanderson (1938-677) Ark.
- lateralis Sanderson (1938-672) E.
- mera Sanderson (1938-682) E.
- mirabilis Sanderson (1938-693) E.
- musgravei Sanderson (1938-698) E.
- märkelii Motschulsky (1854-12) E.
- quadrimaculata Horn (1870-40) E.
  - *sulcata* Blatchley (1910-681)
  - *blatchleyi* Musgrave (1932-57) n.n. for *sulcata* Blatchley (1910, 681) not Grouvelle (1892, 188).
- parva Sanderson (1938-688) Okla. Tex.
- sexlineata Sanderson (1938-663) Kans. Tex.
- sandersoni Musgrave (1940-48) E.
  - *tarsalis* Sand. (1938-675) (not Deleve 1937)
- sinuata LeConte (1852-44) S.E.
- vittipennis Zimmerman (1869-259) E.

Elsianus Sharp (1882-131)
- moestus Horn (1870-37) Elmis SW.
- texanus Schaeffer (1911-119) SW.

Heterelmis Sharp (1882-130)
- glaber Horn (1870-37) Elmis SW.
- obscura Sharp (1882-130) SW.
- vulnerata LeConte (1874-53) Elmis SW.

Microcylloepus Hinton (1935-178)
- browni Hatch (1938-16) Heterelmis W.
- foveatus LeConte (1874-53) Elmis locality?
- moapus La Rivers (1949-205) W.
- moapus fraxinus La Rivers (1949-205) W.
- pusillus LeConte (1852-44) Stenelmis E.
- pusillus apta Musgrave (1932-56) Helmis E.
- pusillus lodingi Musgrave (1932-56) Helmis SE.
- pusillus perdita Musgrave (1932-56) Helmis SE.
- similis Horn (1870-38) Elmis SW.

thermarum Darlington (1928-5) Helmis W.
Neoelmis Musgrave (1935-34)
caesa LeConte (1874-53) Elmis SW.
Hexacylloepus Hinton (1939-181, 1940-331)
ferrugineus Horn (1870-39) Elmis SW.
Cylloepus Erichson (1847-521)
abnormis Horn (1870-38) Elmis SW.
Macronychus Müller (1806-207)
glabratus Say (1825-187) E.
lateralis Melsheimer (1844-99) E.
Zaitzevia Champion (1923-170)
columbiensis Angell (1892-84) Elmis W.
parvula Horn (1870-41) Macronychus W.
thermae Hatch (1938-18) Macronychus W.
Limnius Erichson (1848-522)
latiusculus LeCotne (1866-380) Elmis E.
nitidulus LeConte (1866-380) Elmis E.
Narpus Casey (1893-582)
angustus Casey (1893-583) W.
arizonicus Brown (1930-90) Helmis SW.
concolor LeConte (1881-75) Elmis SW.
solutus Brown (1933-46) Helmis W.
Ampumixis Sanderson
dispar Fall (1925-180) Helmis W.
Cleptelmis Sanderson
addenda Fall (1907-226) Elmis SW.
ornata Schaeffer (1911-120) Helmis W.
Dubiraphia Sanderson
bivittata LeConte (1852-44) Elmis E.
brunnescens Fall (1925-177) Helmis W.
giulianii Van Dyke (1949-54) Simsonia W.
quadrinotata Say (1825-187) Elmis E.
vittata Melsheimer (1844-99) Elmis E.
Gonielmis Sanderson
dietrichi Musgrave (1933-54) Helmis SE.
Heterlimnius Hinton (1935-178)
antennatus Fall (1907-227) Elmis SW.
corpulentus LeConte (1874-52) Elmis W.
koebelei Martin (1927-68) Helmis W.
Optioservus Sanderson
ampliatus Fall (1925-179) Helmis E.
castanipennis Fall (1925-177) Helmis W.
cryophilus Musgrave (1932-79) Limnius E.
divergens LeConte (1874-52) Elmis W.
fastiditus LeConte (1850-217) Limnius E.
immunis Fall (1925-178) Helmis E.
ovalis LeConte (1863-74) Limnius E.
pecosensis Fall (1907-226) Elmis SW.
quadrimaculatus Horn (1870-37) Elmis W.
seriatus LeConte (1874-52) Elmis W.
trivittatus Brown (1930-91) Limnius E.
Promoresia Sanderson
elegans LeConte (1852-43) Limnius E.
subarctica Brown (1930-241) Limnius E.
tardella Fall (1925-179) Elmis E.

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A GENUS OF BEES NEW TO THE ILLINOIS REGION[1]

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In a box of bees sent me by Dr. C. L. Remington of Yale University are three specimens of *Lithurge bruesi* Mitchell, 1927, from Jersey County, Illinois. This is a remarkable record, as the species was hitherto known only from Texas, and the only parts of the midwest from which any species of *Lithurge* has been recorded are the plains states (Kansas, Nebraska, South Dakota). In North America the genus is widespread in the west and evidently occurs across the Gulf States to Florida and North Carolina.

Our species of *Lithurge* appear to be entirely dependent upon cactus (*Opuntia* and its relatives) for pollen. It is therefore not surprising to find them rare in the whole northeastern part of the country where cacti are rare or absent.

The following are new records for *Lithurge bruesi* Mitchell, based primarily upon specimens in the Snow Entomological Museum:

Illinois: Principia College, Elsah, Jersey County, June 5, 1942 (C. L. Remington).

Texas: Quemada, April 11, 1950, on *Opuntia* (Michener, Rozens, Beamers, Stephen); 18 miles north of Harlingen, April 2, 1946, on *Opuntia* (C. D. Michener); 45 miles south of Sonora, April 10, 1950 (Beamers, Stephen, Michener, Rozens); Big Bend, June 23, 1947 (R. E. Elbel); 22 miles south of Laredo, April 15, 1952 (Michener, Wille, La Berge, Beamers); Bishop, April 17, 1952 (Michener, Wille, La Berge, Beamers); Lopeno, April 16, 1952 (Michener, Beamers, Wille, La Berge, Beamers); Uvalde, April 14, 1952 (Michener, Beamers, Wille, La Berge); 10 miles north of Rockport, April 18, 1952 (Michener, Beamers, Wille, La Berge).

From the above it is evident that this is a common and widespread species in Texas.

It should be pointed out that the diagnostic character of the female mentioned by Mitchell in his review of the genus (Psyche, vol. 45, pp. 146-155, 1938) is incorrectly stated in that paper. The structure having a small median emargination and a deeper emargination on each side is the basal elevation of the labrum, not the apical margin of the clypeus.

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STRUCTURAL FEATURES OF COCHROACH EGG CAPSULES IV. THE OÖTHECA OF *PARCOBLATTA UHLERIANA.* (Orthoptera : Blattidae)[1]

FRED A. LAWSON[2]

The oötheca of *Parcoblatta uhleriana* (Saussure) is referred to briefly by Hebard (1917) and by Blatchley (1920). The former states that it "is of an entirely different type from that known for any other species of the genus," while the latter refers to the presence of a groove on either side of the seam. The basic seam structure is typical of that of other Pseudomopines and strongly resembles that of the other *Parcoblatta* species. It is unique, however, in being equipped with a secondary modification in the form of laterally directed, dorsal flanges that over-hang parallel basal grooves which in turn are set off by erect ventrolateral flanges. These structural features are considered here in greater detail along with the complete capsule description which follows.

EXTERNAL

The oöthecae of this species (Fig. 1) are intermediate in size between those of *Parcoblatta virginica* and of *P. pennsylvanica;* they average about 8 x 3.5 mm., with a length range of 7 to 9 mm. The depth was very nearly constant in the rather large series examined. Differences in length probably are due to variation in the number of enclosed eggs; these average 28 per oötheca but fluctuate between 24 and 30. An odd number of eggs is found occasionally in the capsules of this species.

The fully developed color of these egg cases is a deep, chocolate brown; the seam, the thin flanges which are associated with it, and the elevations found on the ends exhibit a dark, reddish tinge when examined by transmitted light. The side walls, however, often are thin and sufficiently transparent to allow direct observation of the developing embryos. This has been observed also in other Pseudomopine species.

Both the dorsal and the ventral margins are curved rather strongly but evenly; the ventral is somewhat the shorter, so that the ends slope inward. In some capsules the lower margin is curved more strongly than is the upper, resulting in greater inward angle at the ends.

The seam and its allied structures are situated directly over the dorsal ends of the enclosed eggs. The midline of the seam (*ld,* Fig. 5) represents the line of closure where the opposing dorsal walls meet and, being of an elastic nature, remain closely appressed to effect enclosure of the ova. The functional units of the respiratory structures are engraved in the opposing mesal faces; the details of these units will be discussed under internal structures.

Externally the middle of the seam is occupied by a median ridge which has a comparatively broad, flat base and which slopes upward mesally to

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form a low crest. This crest (Fig. 6) is interrupted at regular intervals by dorsally pointed, laterally rounded, tooth-like projections (*cbt*, Fig. 6); each of these contains a comma-shaped hollow cell which is located in the center and very near the top. A minute circular hole (*eo*, Fig. 6) penetrates either side of the "tooth" and opens into the cavity; these are located somewhat dorsally and toward the front of the cell.

Each outer margin of the central ridge is marked by a flat, shallow groove which runs the length of the seam. From this groove on either side arises the thin, slightly arched (medially) dorsolateral flange, (*df*, Fig. 4) which forms a curving "roof" over the rather extensive longitudinal trough behind it. The outer edge of this over-hanging shelf may be almost straight, slightly sinuate or evenly escalloped.

The mesal surface of the trough or groove (*g*, Fig. 4), the upper portion of which is also the outside surface of the primary seam walls, slopes outward and downward to the base of the erect lateral flange (*v-lf*, Fig. 4). This structure may be sharply recurved toward the seam, giving the trough an obtuse bottom, or it may extend upward in an evenly rounded arc. Variation between these extremes often is noted.

The lateral flange seldom is straight and smooth, most frequently being evenly sinuate on the upper edge. In these instances, the entire body of the flange usually is molded into corresponding shallow vertical grooves between broad, flat ridges. These usually correspond in longitudinal spacing to the slight ridging of the main capsule wall below; this, in turn, indicates the egg-seats within the capsule.

These grooves or troughs parallel the seam throughout its length. They follow the curvature of the capsule as they extend around and out on the ends, where they terminate just short of the vertical center line. The margins of the dorsal flange retreat mesally as the ends of the seam are approached; this takes place gradually on the distal extremity and more abruptly on the proximal. The general result is a slender tapering at the caudal termination of the seam, while the other end is more broadly wedge-shaped. The lateral flanges are cut off squarely at the ends and the upper corners often are turned inward. The distal ending of the central seam-bearing element is thin and blade-like, while that of the proximal is smoothly rounded. A considerable range of variation in these structures was noted.

The Y-shaped markings typical of the Pseudomopine oöthecae are hidden from view by the flanges enclosing the trough. These are internal lines and ridges which mark the postmesal terminations (*et*, Fig. 9) of the eggs that occupy the opposite half of the capsule. This set of configurations is visible near the top of the inner face of the groove. The lateral flanges arise from the capsule wall at a distance below the seam which is about twice that enclosed by the arms of the Y.

The distal and proximal ends of this species are easily determined; the former is shaped up when the first portion of capsule wall materials is secreted into the vestibular cavity and probably takes on its definitive shape before any eggs are deposited. The conformations of the proximal ends are molded by the distal parts of the ovipositor, with the aid of surrounding tissues, after the last egg has been placed.

The distal end of the egg case is characterized by a thin, blade-like extension of solidified capsule material (*def*, Fig. 4) which dorsally is continuous with the end of the seam. This "flange" is semitransparent in transmitted light and is easily distinguished from the darker main body of the capsule. The side-view profile of this end-ridge in all capsules is notably irregular and of variable height; the nature and degree of this variation differ in almost every capsule. The general pattern is as follows: immediately below the seam termination is an area which comprises one fourth to one half the flange depth, uually exhibits the greatest outward extension from the seam body, and which normally is toothed, serrate, or sinuate in outline; this usually is followed by an area of decided reduction in outward extension, in which the highly variable outer margin approaches (and sometimes reaches) the wall of the capsule; the third and last portion is composed of a second extension which usually comes to a sort of point and then either gradually or precipitously drops back to merge with the capsule body. This latter division is also variously toothed or sinuate. Vertically this terminal ridge traverses from one half to almost all the capsule end-face; the lateral (side-to-side) thickness is consistently narrowed.

The proximal profile is likewise variable but the structural components are not so prominent and fluctuate less extensively. This end is perhaps better characterized by its comparative lack of seam-termination and end-face structures. Most prominent of the structural features found here is the small raised triangular point or hilum (*h*, Fig 2) situated immediately below the horizontal midline of the oötheca. This, too, is a semi-transparent, reddish brown continuation of capsule substance. Its dorsal extremity usually originates at or near the middle of the end-face. This small elevation, although occupying a relatively fixed position, varies considerably in both vertical and side-to-side dimensions. Among the different capsules it was found to vary from almost non-existent to approximately the size shown in Figure 2. Generally no raised structures are seen in the profile view of that portion of the end-face between the seam termination and the upper margin of the hilum.

End views. Even though the side or profile views are sufficient for distinguishing between the two ends, the following brief details of the end-on aspects are included as additional aid for the identification of the capsules of this species.

Distal. The central element of the seam here tapers to a sharp edge termination. The blade-like continuation of the main seam element continues down the end-face to a level usually below the mid-line; here it gradually loses altitude and blends into the capsule wall. The grooves which parallel the seam are slightly deeper on this end than on the proximal.

Proximal. The cell-bearing median area terminates as a broad, and usually rounded, surface which is then continuous with the vertical end-face of the main inter-groove seam body. In some capsules, however, a thin, slightly elevated ridge may extend downward to a level about even with the corners of the lateral flange terminations. The floor of the grooves usually is somewhat wider at this end.

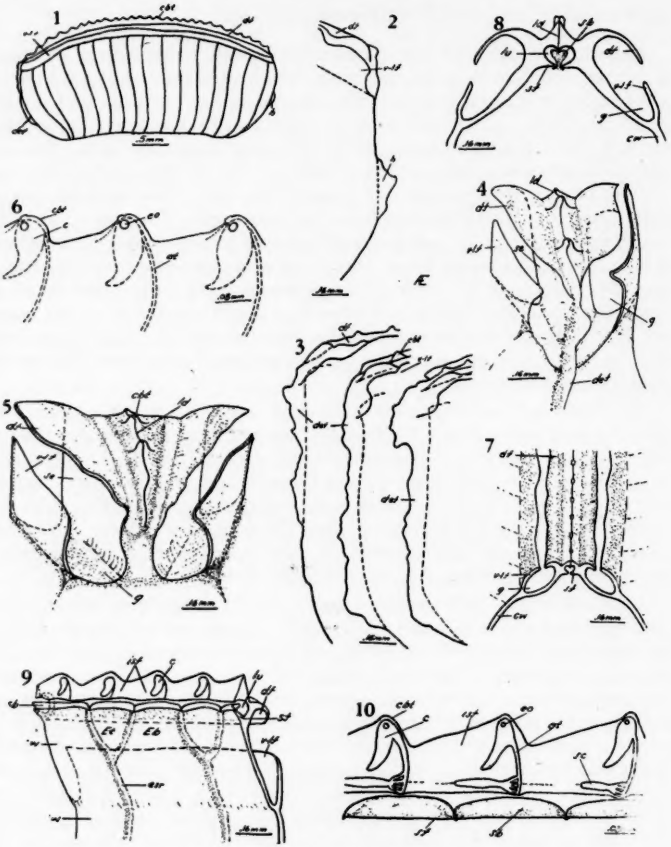
INTERNAL

The extreme upper margin of each capsule wall is marked, on its inner surface, by a shallow longitudinal groove which separates two layers known as the upper and lower laminae. The upper laminae form the roof of the seam lumen (*lu*, Fig. 8); each extends upward and slopes inward to inclose one half of the triangular seam cavity. The mesal extremity of this layer is reflexed downward to form a vertical face (*isf*, Fig. 9); this with the corresponding part on the opposite side, comprise a rather thin, blade-like, ventrally directed median extension from the lumen roof. The ventilating cells and tubes (*c, at*, Fig. 10) are engraved into the glassy smooth median face of each half of this inside flange; the lateral openings to the exterior extend from the cell through the outer surface of the dorsal laminae. These aerating structures are located within the tooth-like dorsal extensions of the seam roof layers. The ventral extensions of the inverted median ridge reaches low into the lumen and may touch the top of the spongy inclusions. This lower margin usually is sinuate.

The lower laminae branch inward at their separation from the upper and form the seam floor (*sf*, Fig. 8). Usually each is thinner than the dorsal layer and may taper briefly as it extends inward and slightly upward. There may be a pronounced wrinkle at the point where adjoining choria separate neighboring ova. These "floor" layers, or inner laminae, do not quite meet on the center line; this leaves a thin longitudinal slit through which the ventral extensions of the spongy bodies within the seam lumen connect with the dorsal cap layer of the eggs below (i.e., the sub-floor layer).

Each cell half is comma-shaped and is about twice as deep as long. The greatest lateral width is found in the upper regions from which the lateral openings extend; the lower part of the cell is tapered inward to give a wedged ventral termination. The distal margin of each cell half is continuously rounded as it curves downward; the proximal margin shows a rounded, expanded upper portion followed by a recurving toward the distal which in turn is succeeded by a return curvature that carries this margin out and down to the pointed lower tip of the cell engraving. The tube half rises at variable levels on the upper portion of the distal cell margin; it arches slightly outward from the cell and reaches downward through the remaining vertical seam face extension. The tube half may be strongly arched or it may extend nearly straight throughout its descent. The lower extremity usually is directly below the cell or slightly distad of it. Since each assembled tube terminates directly above one of the egg-capping spongy bodies, there is at least one complete respiratory unit for each enclosed egg; on rare occasions an additional set or two may be found.

A third type of engraving (*sc*, Fig. 10) has been observed on the inflexed mesal seam face; it has not been seen in capsules of any other species examined. This is a longitudinal impression, located very near the lower edge of the inflexed surface; it is directly below the hollow cell and is cephalad of the tube half. Each structure is somewhat foot-shaped with the narrowed "heel" portion cephalad. In most capules the impression widens briefly *and* deepens considerably in the middle area. From here it becomes more shal-



ABBREVIATIONS USED IN PLATE

at—air tube
c—cell
cbt—cell-bearing tooth
cw—capsule wall
def—distal end flange
df—dorsal flange
eb—egg body
eo—external opening
esr—egg-space ridge
et—egg termination
g—groove
h—hilum
isf—inflexed seam face
ld—line of dehiscence
lu—lumen of seam
sb—spongy body
sc—secondary cell
se—seam
sf—seam floor
v-l f—ventro-lateral flange

low and terminates in a posterior curved margin near the anterior edge of the tube. The intervening space is traversed by three to five shallow but distinct radiating grooves which correspond to the toes of the foot. The lowest of the grooves may extend downward sufficiently to open on the lower margin of the inflexed ridge, rather than in the tube. These oppositely placed engravings thus form, in the assembled capsule, a second hollow cell, longitudinally placed and connecting with the gas-delivering tube. This no doubt represents an additional modification of female structure but is one which is not so strongly developed as are those which result in the external flange-and-groove arrangement.

The spongy bodies (*sb*, Fig. 10), which occupy a prominent place in the seam lumen of capsules of the Pseudomopinae, have been shown by Wigglesworth and Beament (1950) to be structures closely associated with the egg as a part of its respiratory system. In this species they are long, shallow, and comparatively narrow. They usually are light tan in color. Each rounds off at the ends and the terminal margins extend downward into the seam-floor wrinkles. The longitudinal center line of the base of each is connected by a thin extension between the seam floor plates to a thin layer on top of the eggs below. Gaseous exchange takes place through these structural provisions.

The lumen of the seam is longitudinally continuous throughout its length but is loosely partitioned down the middle by both the inflexed seam ridge and the row of egg-capping spongy bodies. The inner face of the roof of each lateral space often is marked with broad ridges extending distally and upward; these, when present, are located directly beneath the cells. The posterior margin of each ridge is marked by a sharply defined but shallow groove. The ventral termination of the latter is in the deepest portion of an out-pocketing of the lumen. Due to the median inclusions and this ridging of the lateral internal surfaces, the side spaces of the lumen are considerably reduced.

The lower surface of the seam floor layers (lower laminae) are marked by the Y-shaped lines which delineate the positions of the eggs. The ova, which are placed alternately in either side of the egg case and overlap slightly on the center line, evidently are squeezed tightly into place as deposited. This is indicated by internal ridges (*esr*, Fig. 9) which extend vertically up the side walls and are continuous in substance with the latter. Each represents an invagination of capsule wall-substance which while soft was squeezed in

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EXPLANATION OF PLATE

Fig. 1. Oötheca of *Parcoblatta uhleriana* (Sauss.), side view.
Fig. 2. Profile view of proximal end-face of oötheca.
Fig. 3. Profile view of distal end-faces of three egg cases, showing variation in terminal flange.
Fig. 4 Distal end of seam and grooves.
Fig. 5. Proximal end of seam and grooves.
Fig. 6. Side view of seam, highly magnified, in transmitted light.
Fig. 7. Dorso-sectional view of seam and grooves.
Fig. 8. Cross-section of seam and grooves.
Fig. 9. Internal, ventro-mesal view of seam and upper egg-space of capsule proper.
Fig. 10. Mesal view of inflexed seam face and spongy bodies, highly magnified.

between the outer margin of the eggs. The degree of inward extension of these ridges will vary from one capsule to another but is substantial in all. This ridged arrangement evidently serves a secondary function of reinforcement of the capsule walls, since these can withstand considerable external pressure.

The position of the base of the lateral external flange is indicated by an interruption of the smooth upward curvature of the side wall. This is seen as a line running the length of the capsule and also marking the lower limit of the outside "groove." Above this line the walls bend rather abruptly inward and gradually upward to the seam.

As in other oöthecae of this subfamily, the egg-shells are left standing erect as thin-walled "pockets" in the hatched egg case; these pockets are double where the choria of adjoining eggs are pressed together but are found as a single layer over the inside faces of the capsule walls. The hexagonal trabecular pattern is faintly visible and indicates the presence of either single or double layers of chorion. The egg shells appear to have the same tawny color as do the spongy bodies and this tends to obscure the patterns of the trabeculae.

The matrix of the capsule walls usually is somewhat translucent and in transmitted light reveals the presence of a great number of minute embedded crystals. These, according to some of the earliest investigators, are calcium oxalate inclusions.

SUMMARY

The egg case of *Parcoblatta uhleriana* is described; this oötheca is unique in that it is provided with longitudinal grooves which parallel the seam on either side. Each of these is delineated by a dorsal and a ventrolateral flange; the flanges are composed of capsule wall substance and are basally continuous with the seam top and with the upper capsule wall, respectively.

The space enclosed as the seam lumen is considerably reduced, a condition due to thickened laminae and a set of raised sculpturings on the inside face of the seam roof. The spongy egg caps are tan in color and are long, low, and rather slender; each end curves down into a slight fold which separates the adjoining tops of the tightly packed eggs.

In trabecular pattern, in matrical inclusion of calcium oxalate crystals and in basic structural organization this capsule is typical of those produced by other Pseudomopine roaches.

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WEIGHT DIFFERENCES IN SOUTHWESTERN CORN BORER LARVAE, *DIATRAEA GRANDIOSELLA* DYAR, REARED ON TEOSINTE IN KANSAS IN 1952[1]

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The weights of hibernating larvae of the southwestern corn borer removed from open pollinated corn and from sorghum stalks have been found to differ significantly[3]. However, the largest larvae removed from corn weighed nearly four times as much as the smallest ones, suggesting that important differences exist between corn plants in respect to nutritive values to the southwestern corn borer. Since ordinarily only one larva is removed from each corn plant there is no opportunity afforded for statistical comparisons.

Teosinte,[4] when grown in northern latitudes, does not grow in individual stalks as does corn, but rather in bunches, consisting of a number of branches, each of which usually harbors a single larva. In a few rare instances, two larvae were found in a single branch in which case they were excluded from the calculations of weights given below.

Two replications of teosinte[5] were planted at the Kingman Kansas Experiment Field in the spring of 1952. On November 15, 1952, 10 individual teosinte plants were dug and brought to Manhattan, Kansas. These plants were dug at random and although two of the plants were slightly smaller than the remaining eight, there were no evident visual differences between plants.

At Manhattan, the 10 plants were dissected carefully and the southwestern corn borer larvae were removed and each weighed separately. These weights were kept separate for all larvae found in each of the 10 individual plants.

It was thought that there might be a possibility that some of the plants of teosinte might carry a gene or genes responsible for some degree of resistance toward the southwestern corn borer. Significant differences in larval weights might be a result of such genetic differences.

Results.—Since 10 plants were involved in which 4 to 23 larvae were found in each plant, the larval weights were placed in 10 respective groups (Table 1). The average of the 10 group means was 198.34 milligrams. The range of the group means was from 132.88 to 264.14 milligrams.

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[1] Contribution No. 610, Department of Entomology. Studies conducted at the Kansas Agricultural Experiment Station in connection with Project 284 Hatch and Purnell 164.

[2] Instructor and Professor respectively in the Department of Entomology, Kansas State College, Manhattan, Kansas.

[3] Wilbur, D. A., H. R. Bryson and R. H. Painter. Southwestern corn borer in Kansas. Kans. Agr. Expt. Sta. Bul. 339, 46 p. 1950.

[4] *Euchlaena mexicana.*

[5] The teosinte seed was obtained through the courtesy of Doctor I. E. Melhus of the Iowa Tropical Research Center in Guatemala.

TABLE 1. Weights of southwestern corn borer larvae in 10 individual plants of teosinte in Kansas.

	Plant Number									
	1	2	3	4	5	6	7	8	9	10
No. of larvae	9	8	6	7	23	15	21	18	4	10
Ave. wt. of larvae (mg.)	132	192	144	264	200	224	258	210	164	192
Range in wts. of larvae (mg.)	83 to 233	135 to 259	92 to 223	123 to 393	111 to 303	120 to 325	176 to 366	116 to 303	141 to 199	126 to 277

There appeared to be no significant correlation between diameter of stem and size of larvae. Even very small stems contained larvae of average size (Fig. 1).

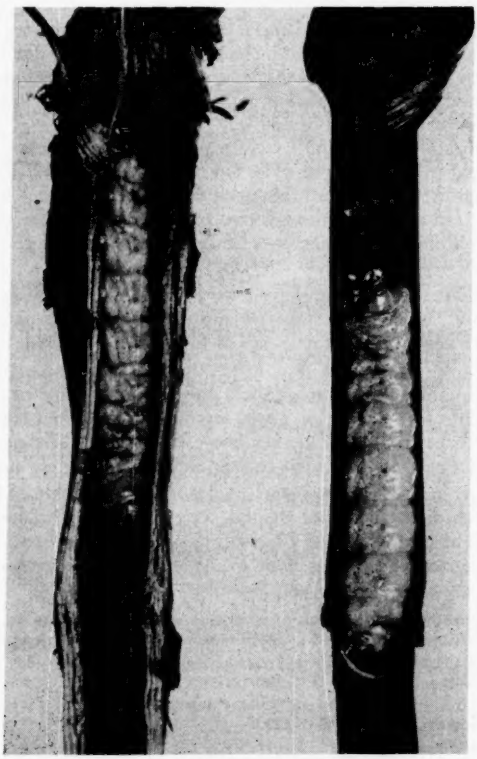

Fig. 1.—Normal sized southwestern corn borer larvae in comparatively small stems of teosinte.

The mean weight of all individual larvae was 208.35 milligrams. Considering all larvae as a group, 56 of the larvae weighed more than 208.35 while the remaining 65 larvae weighed less. The individual larval weights ranged from 83 to 393 milligrams. The weighted average weight of larvae was 208.35 milligrams. The average weights of 57 borers in nearby corn (Kansas K1830) was 213.7 mg.

The data concerning the weight difference of southwestern corn borer larvae in teosinte were analyzed and subjected to the F-test. The F value obtained was 5.44 as compared with the value of 2.58, necessary to show significance at the 1 per cent level.

Conclusions.—Highly significant differences in weights of southwestern corn borer larvae were recorded where the larvae were reared on different teosinte plants. No significant differences were found between weights of larvae from the same plant.

Ordinarily in corn only one larva per plant matures but wide differences in weights of individual larvae on single plants have been observed. The differences in weights among groups of larvae that have fed on individual plants of corn may also be highly significant, and represent inherent resistance.

NOTES ON THE SPECIES OF DROSOPHILIDAE (DIPTERA) OCCURRING IN KANSAS

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Snow (1903) listed one species of genus *Drosophila* from Kansas. In 1905, Crevecoeur recorded one species of the genus *Scaptomyza*. Tucker (1906) added one genus and four additional species to the list. Sturtevant (1921) listed two genera and 12 species. Patterson (1942) recorded one species; and Patterson and Wagner (1943) recorded 2 species of *Drosophila* that occur in Kansas. During the years of 1950 and 1951, one genus and 11 unrecorded species of Drosophilidae were found by the writer and with aid of friends, on various fruits and plants in Kansas. Species of Drosophilidae were determined by Dr. Marshall R. Wheeler of the University of Texas.

The species collected in Kansas may be placed in three general categories: the general scavengers, the fruit-feeders, and the fungus-feeders. The general scavengers fed on decaying vegetables (such as potatoes, tomatoes, cucumbers) and refuse in garbage cans (such as bacon, meat, gravy, etc.). The species found on decaying vegetables were *Drosophila funebris, Drosophila tripunctata, Drosophila putrida, Drosophila melanogaster,* and *Scaptomyza adusta.* These species were collected either through rearing from the

[1] This work was done at Kansas State College under the direction of Dr. R. H. Painter and represents a portion of a master's thesis submitted to that institution.

infested hosts or trapping near the decaying food. Those species feeding on the refuse in garbage cans were *Drosophila funebris, Drosophila americana, Drosophila buscki, Drosophila affinis, Drosophila hydei* and *Drosophila melanogaster*. All of these species were first collected in 1951 during the month of May.

The fruit-feeders, such as *Drosophila melanogaster, Drosophila affinis, Drosophila hydei* and *Drosophila americana,* were attracted to garbage cans probably due to the unavailability of native foods during early summer. The friut-feeders fed largely on the available fruits, either native or cultivated, such as pear, peach, persimmon, apple, wild grape, cultivated grape, crab apple, prickly pear, pokeweed, and virginia creeper.

The fungus-feeders were found on bracket fungus and ink cap mushrooms (*Coprinus* sp.) in Manhattan. Apparently most of the fungus species fed and bred in the warm summer months because few were collected during the late summer and early fall. This group included the following species: *Drosophila putrida, Drosophila hydei, Drosophila affinis,* and *Mycodrosophila dimidiata.*

As attractants, culture media and fruits available in nature were placed in mayonnaise jars as traps in the Manhattan area and in other localities in several counties in Kansas. Flies were also collected by sweeping the net over the infested vegetables and fruits. Various hosts, such as fruits, fungi, and plant parts possibly infested by Drosophilidae were collected and insects reared in the laboratory.

It is of interest to compare the Drosophilid fauna of Kansas with that of the four states bordering Kansas. Patterson (1943) recorded 18 species from Missouri; among these, 10 were the same as those known from Kansas; 14 species now known from Kansas were not recorded from Missouri. Collections made by Patterson (1943) in Oklahoma included 22 species; there were 12 species now known from Kansas which were not recorded in Oklahoma. Patterson (1943) collected 14 species in Colorado, of which 9 were similar to those of Kansas; 15 species from Kansas were not recorded in Colorado. Williams (1948) listed 22 species and Williams and Miller (1952) added to the list 9 more species from Nebraska; 19 of these were identical to Kansas species; 4 Kansas species were not recorded from Nebraska. Three species of Drosophilidae collected in Kansas were not recorded from any of the four bordering states. These species were: *Mycodrosophila dimidiata, Leucophenga maculosa,* and *Leucophenga varia.*

LIST OF KNOWN SPECIES OF DROSOPHILIDAE IN KANSAS

Mycodrosophila dimidiata Loew 1862
Riley Co., Sept., 7 specimens; collected and reared on fungus (bracket) (Yoshimoto).

Aulacigaster leucopeza Meigen 1830
Sturtevant (1921) recorded this species from Kansas.

Leucophenga maculosa Coquillett 1895
Sturtevant (1921) recorded this species from Kansas.

Leucophenga varia Walker 1849
Recorded from Kansas by Sturtevant (1921).

Chymomyza amoena Loew 1862
Tucker (1906 and Sturtevant (1921) listed this species from Kansas. A specimen from Kansas State insect collection dated April 29, 1934, McPherson Co.; Lyons Co., Sept., 2 specimens; McPherson Co., Sept., 3 specimens; collected on apple and pear (Yoshimoto).

Chymomyza procnemis Williston 1896
Sturtevant (1921) recorded this species from Kansas.

Scaptomyza adusta Loew 1862
Tucker (1906) and Sturtevant (1921) recorded this species from Kansas.

Scaptomyza graminum Fallén 1823
Tucker (1906) and Sturtevant (1921) recorded this species from Kansas.

Scaptomyza vittata Coquillett 1895
Crevecoeur (1905) recorded this species from Kansas.

Drosophila:

D. affinis Sturtevant 1916
Sturtevant (1921) recorded this species from Kansas. Barton Co., Sept., 2 specimens; Lyons Co., Sept., 1 specimen; Riley Co., May, 1 specimen, Sept., 33 specimens; collected on apple, banana, crab apple, persimmon, garbage, and reared from crab apple (Yoshimoto).

D. algonquin Sturtevant and Dobzhansky 1936
Riley Co., Sept., 1 specimen, Oct. 2 specimens; collected on banana and crab apple (Yoshimoto).

D. americana Spencer 1938
Patterson (1942) recorded this species from Western Kansas. Riley Co., May, 1 specimen, Sept., 9 specimens; collected on garbage, banana, persimmon, and apple (Yoshimoto).

D. athabasca Sturtevant and Dobzhansky 1936
Riley Co., Sept., 13 specimens; collected on banana and crab apple (Yoshimoto).

D. buscki Coquillett 1901
Sturtevant (1921) recorded this species from Kansas. Doniphan Co., Sept., 15 specimens; Riley Co., May, 13 specimens, Sept., 15 specimens; collected on banana, garbage, and pear (Yoshimoto).

D. funebris Fabricius 1787
Tucker (1906), Sturtevant (1921) and Patterson and Wagner (1943) recorded this species from Kansas. Barton Co., Sept., 6 specimens; Riley Co., Sept., 10 specimens, Oct., 5 specimens; collected on grape, pear, fungus, tomato, and banana; reared from persimmon and from fungus (Yoshimoto).

D. guttifera Walker 1849
Riley Co., Sept., 1 specimen; collected on mushroom (Yoshimoto).

D. hydei Sturtevant 1921
Doniphan Co., Sept., 8 specimens; Riley Co., Sept., 4 specimens; Oct., 17 specimens; May, 2 specimens; collected on garbage, pear, persimmon and fungus; reared from persimmon (Yoshimoto).

D. immigrans Sturtevant 1921
Doniphan Co., Sept., 2 specimens; collected on pear (Yoshimoto).

D. melanica Sturtevant 1916
Riley Co., Sept., 5 specimens; collected on banana and crab apple (Yoshimoto).

D. melanogaster Meigen 1830
Snow (1903) and Sturtevant (1921) recorded this species from Kansas. Barton Co., Sept., 9 specimens; Doniphan Co., Oct., 68 specimens; Finney Co., Oct., 32 specimens; Lyons Co., Sept., 5 specimens; Cloud Co., Oct., 8 specimens; Cowley Co., Sept., 23 specimens; Hamilton Co., Oct., 30 speci-

mens; McPherson Co., Sept., 35 specimens; Montgomery Co., Sept., 12 specimens; Neosho Co., Oct., 25 specimens; Osborne Co., Oct., 10 specimens; Riley Co., Sept., 450 specimens, Oct., 259 specimens, May, 38 specimens; Thomas Co., Oct., 30 specimens; Wallace Co., Oct., 25 specimens; collected on banana, cucumber, mushroom, tomato, crab apple, persimmon, grape, apple, peach, wild grape; reared on all of these plus pokeweed, prickly pear, and virginia creeper (Painter, Smith, Yoshimoto).

D. putrida Sturtevant 1916

Patterson and Wagner (1943) recorded this species from Kansas. Specimens from Kansas State insect collection dated Oct. 5, 10, 1932; Douglas Co.; Riley Co., Sept., 15 specimens; collected on banana, cucumber, mushroom (Yoshimoto).

D. repleta Wollaston 1858

Specimen from Kansas State insect collection dated Sept. 8, 1949, Riley Co. Doniphan Co., Sept., 4 specimens; Riley Co., Sept., 13 specimens; collected on grape, crab apple, and banana (Yoshimoto).

D. robusta Sturtevant 1916

Riley Co., Sept., 8 specimens; Oct., 3 specimens; collected on persimmon and banana (Yoshimoto).

D. simulans Sturtevant 1919

Riley Co., Sept., 2 specimens; collected on mushroom (Yoshimoto).

D. tripunctata Loew 1862

Riley Co., May, 1 specimen; Sept., 3 specimens; collected on tomato, garbage, and mushroom (Yoshimoto).

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THE GARDEN WEBWORM—*LOXOSTEGE SIMILALIS* GUEN. AS AN ALFALFA PEST IN KANSAS[1]

ROGER C. SMITH AND W. W. FRANKLIN[2]

The presence of garden webworms in alfalfa is indicated by strands of silk tying the terminal leaves of the main stems and lateral branch stems of alfalfa and many other kinds of plants to form nests or compact enclosures, (Fig. 4). Eventually the entire plant may appear as if it had been seared with a flame. Thin webs may occur on the surface of the ground surrounding the base of plants following the removal of the preceding hay crop; or they may appear also in newly sown alfalfa fields in early fall but they should not be confused with the webbing of *Nomophila* (Smith, 1942). Yellowish-green, black-spotted larvae of the garden webworm feed within these webs (Fig. 3). They are readily confused with the beet webworm (Fig. 2) and the alfalfa webworm (Fig. 1).

The garden webworm has been one of the major pests of alfalfa, corn, and gardens in Kansas for the last 35 years and this paper records observations on its life history, habits, and control which cover a period of 32 years. This is a widely known and distributed pest. It occurs over all of Kansas, as well as over most of the United States and South America. Poos (1951) stated that the most serious damage occurred in California, Nebraska, Iowa, Missouri, New Mexico, Kansas, Oklahoma, and Texas. The garden webworm was first noticed on weeds in Central Missouri in June 1914 (Haseman, 1920). It attacks numerous plants, including many kinds of weeds. It is commonly stated that this insect prefers pigweeds, going to alfalfa only when the weed foliage is destroyed. In recent years, alfalfa on numerous occasions has been almost completely consumed while pigweeds in adjacent fields were only partially attacked.

Seasonal History—The manner of overwintering of the garden webworm is not definitely known, but it is the general impression that it winters in Gulf states as a pupa. Adults have been taken as early as the latter part of March at Manhattan and they regularly occur in April and May and are always battered and badly worn.

Attempts to overwinter this species at Manhattan have been uniformly unsuccessful. Large numbers of adults were either caged or placed in vials and stored under a variety of conditions, but they usually died before December 1. Larvae and pupae likewise have died during the winter. Eggs in cages hatched soon after deposition, if they hatched at all.

First brood larvae begin to appear in the alfalfa fields in early May and are mature by the latter part of May, the moths appearing early in June. The second generation moths appear the last of June and continue to the middle July. These moths give rise to the second generation larvae which attack the second or third alfalfa cuttings, usually the second, and do more or less ser-

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ious injury, depending on their numbers. This attack occurs early in July. The third generation adults begin to appear late in July, and continue throughout August. Few eggs are deposited by this rather large brood of moths although a light third brood of larvae is produced which can be taken during September and October. Adults occur at all times during these months, and up to killing frosts. Most of these third generation larvae succeed in transforming to pupae and probably to adults, though some are killed by the frost. There are, therefore, three complete generations a year in Kansas, the second generation ordinarily being the one causing the greatest amount of injury. Sanborn (1916) stated that there are four or five generations in Oklahoma and that the last brood did not spin webs.

Life Stages—The eggs are deposited in flat scale-like masses which are gray in color (Dean and Smith 1935). In cages, these masses are readily deposited on or more commonly, under the leaves, but they are also deposited on the stems. The masses contain from 1 to 37 glassy or grayish, flat, nearly circular eggs which appear to overlap the other eggs, making up the mass. The eggs average 0.64 mm. in diameter, but some on the outside of masses measure as much as 1.1 mm. the long way. Under magnification, small pentagonal or hexagonal designs with raised edges can be seen on the chorion. The enclosed areas are shining. As development proceeds, they become dull brownish, then smoky black. Just before hatching, they become quite dark and the black heads of the larvae become visible. Hatching is effected either by eating or breaking a hole in the eggshell at the edge or by lifting up the top of the egg sufficiently to enable the larvae to crawl through the opening. The period of embryonic development varies from two to five days during the summer (Table 1).

The larvae are active creatures, light to dark greenish-yellow in color, and have three paris of prominent black spots on most of the segments (Fig. 3). A single seta arises from a small papilla which occurs in each spot. The young larvae eat together during the first instar then scatter and web the leaves and stems in the top of the alfalfa plant within which they feed upon the foliage (Figs. 4, 5, 6). Copious excrementitious black pellets occur in the webbing and render badly damaged hay of small value. When disturbed, the larvae take on a spasm of aimless wriggling which assumes proportions of violence for such small creatures. They throw themselves out of their webs and fall to the ground or drop on silken threads. There are six instar stages of development. A summary of the width of the head and the length of the larvae in the various instars is given in Table 2.

Larvae of the first two instars eat only the epidermis of the under sides of leaves, while later instars consume the entire leaf, usually beginning at the border. They spin some silk soon after hatching. The results of their feeding are quite inconspicuous during the early instars, but in the last two or three instars, both webbing and defoliation are readily observed. The larvae feed largely or wholly during the day. When numerous, there is a web in practically every plant, and during outbreaks several larvae in every plant. Such infested alfalfa has a lighter green color when viewed from a distance. Upon coming closer, the lack of foliage and the ragged appearance of what remains become evident. The webbing, however, is characteristic of this species but

TABLE 1. Length of time required for each larval stage of the garden webworm in rearings at the field insectary at Manhattan, Kansas during July and August.

Stage	Duration, Average days	Maximum No. of days	Minimum No. of days	No. of individuals averaged
Egg	2.8	3	2½	10
Larva	15.9	28	14	29
Prepupa	1.5	3	1	10
Pupa	8.7	13	4	23

TABLE 2. Summary of instar measurements of the garden webworm.

Stage		Average	Maximum	Minimum	No. of larvae averaged
1st instar	(Width of head	0.254mm.	0.26mm.	0.2mm.	30
	(Lenth of larva	2.1	2.5	1.6	
2nd instar	(Width of head	0.37	0.4	0.325	30
	(Length of larva	3.7	4.3	2.2	
3rd instar	(Width of head	0.58	0.7	0.55	21
	(Length of larva	6.1	9.3	4	
4th instar	(Width of head	0.92	1.0	0.8	30
	(Length of larva	9.5	13	6.6	
5th instar	(Width of head	1.10	1.2	1.05	30
	(Length of larva	11.03	14	9	
6th instar	(Width of head	1.34	1.5	1.25	30
	(Length of larva	13.4	20	9	

not a positive identification because the alfalfa webworm (Fig. 1), the beet webworm, *Loxostege sticticalis* (Fig. 2), a geometer—*Haematopsis grataria,* and certain Tortricids also make webbed nests in alfalfa, but their numbers are generally less.

When fully grown, the larvae enter the soil and spin cocoons of silk which extend vertically or nearly so just below the surface of the soil, the upper end often being continuous with it. In cages, they merely crawl below the leaf trash on the ground and form cocoons. The larvae pupate within these cocoons which occur, primarily, around the base of alfalfa plants. The pupal cases are thin and flat, brownish in color, nearly transparent, smooth, and measure on the average 12.5 mm. in length and 3.5 mm. in width. The

cocoon is closed below, but the upper end is open. They are thickly encrusted with soil when dug up.

The pupa is green at first, turning brown gradually until it is a rich reddish-brown. It measures on the average about 8 mm. in length. At the end of the abdomen are three short, stout spines. The average length of the pupal stage is 10 days. The adult emerges by forcing its way through the open end of the cocoon to the surface of the soil. It immediately crawls up a plant and awaits the expansion of the wings which requires approximately an hour.

The moths have a wing spread of approximately half to three-quarters of an inch (Dean and Smith 1935). They are yellowish-brown in color and grayish beneath. There are several zig-zag, brownish or blackish lines across the front wings which are often reduced to spots. The hind wings are light yellowish-brown throughout, except for some smoky-black spots near the margin.

The wings, when folded, nearly form an isosceles triangle in outline. When a person walks through a field, the moths fly up ahead for a distance of 3 to 10 yards then drop down excitedly and seek shelter on the under side of the leaves or on the lower parts of the plant. They are rarely seen during the day unless disturbed, but they become active in the evening and remain so at least during the early part of the night.

Copulation was not observed during the period of this study. There is a preoviposition period of approximately four days, after which a maximum of 493 eggs, judging from an ovule count, may be deposited. Usually only a few eggs were deposited in cage rearings, the maximum being 170 eggs. The adults are short-lived, except in the fall when they could be kept alive for a month or more. Usually they died within two weeks, the majority dying in two or three days.

Food Plants—Garden webworms feed upon a great variety of plants. During the outbreak of 1923, they were taken on practically all kinds of garden truck—such as Irish and sweet potatoes, melons, tomatoes, cabbage, cauliflower, spinach, onions, radishes, and peppers. They attacked the fruit of the melons as well as the flowers. They were common on many kinds of weeds such as the giant ragweed, *Ambrosia trifida,* and the common ragweed, *A. artemisifolia* L.; on lambsquarters, *Chenopodium album* L.; on pigweeds, *Amaranthus* spp.; smart weeds, *Polygonum* spp., both narrow and broad-leafed dock, *Rumex* spp., and many other kinds of weeds. No plants in the heavily infested areas were clearly immune. Alfalfa appears to be its favored food plant and not weeds, as is so often stated. It was observed that certain varieties of alfalfa at the College farm were more heavily injured by this insect during the outbreak of 1923 than were others. This difference was thought to have been due to difference in the stage of growth of the different varieties at the time of maximum egg laying, rather than to any differences inherent in the varieties of alfalfa. The moths of this species feed at alfalfa blossoms from late in the day until dark.

CONTROL

Natural Enemies—This insect is attacked by what appears to be the same bacterial and fungus diseases which attack many of the other alfalfa insects.

These diseases, however, are not common, and are, therefore, not major factors in the control of this pest.

Parasites—Bracon vulgaris Cress (Faur.) (Fam. Braconidae, Det. A. B. Gahan) was reared a few times during August, 1919 and 1920. It emerged from the webworm cocoon. *Cardiochiles explorator* (Say) (Fam. Braconidae, Det. A. B. Gahan) was reared during July several times. *Nemorilla maculosa* (Meig.) (Fam. Tachinidae) was reared from a larva in August, 1924. It was 14 days in the pupal stage. *Winthemia quadripustulata* (Fab.) (Fam. Tachinidae) was reared many times from parasitized larvae. The pupal stage normally lasted 12 to 15 days.

Predators—Birds such as grackles, robins, and several varieties of sparrows were the chief predators seen. They devour larvae especially after the alfalfa is cut while these and other caterpillars which attack alfalfa are crawling about on the ground or on the curing hay.

Cultural Control—The usual recommendation for the control of the garden webworm formerly was to cut the alfalfa as soon as it began to show severe injury. The crop is thereby saved and the larvae are forced to migrate to other sources of food or perish. In so doing, most die from exposure or are caught by birds and other predators. This has worked out very well in general in controlling the insect (Fig.7). However, Granfield (1951) reported that cutting alfalfa much before the full bloom stage results in injury to the plant, which brings about a reduction in the stand and encroachment of grasses.

Chemical Control—A series of experiments have been under way in Kansas to control these pests by use of the newer insecticides. Plots were first laid out in 1947 on the Agronomy Farm at Manhattan, Kansas. One plot was dusted with 1.65 pounds of actual DDT to the acre. This plot was paired with an untreated check plot. Garden webworm larvae were just beginning to damage the alfalfa at the time the insecticide was applied. Ninety-five percent control was obtained and the final results are shown in the comparison of seed yields. The treated plot yielded 130 pounds of seed per acre while the check plot yielded only 45 pounds per acre, an increase of 298 percent. During the 1947 season the third generation larvae attacked alfalfa at Manhattan which is somewhat unusual. Also unusual in this year were the webs which this generation placed on seedling alfalfa and anchored to the soil surrounding the plants. Plots 15 by 40 feet were staked out in an alfalfa field using insecticides and rates as given in Table 3. Since the stand of the alfalfa was thin, the sweep net method of population sampling was discarded and counts made on the square yard basis. The insecticide applications were made with a Root rotary hand duster on August 29. DDT used at the rate of 2.8 pounds per acre gave 96 percent control, at 4.6 pounds per acre 93 percent control and 9.1 pounds per acre 98 percent control at the end of one day. Rotenone, Rhothane, and Cryolite gave 27 percent, 36 percent, 29 percent control, respectively.

The best control for the five day period resulted from the use of DDT applied at the rate of 9.1 pounds per acre. The next best control was given by the combination of DDT-BHC which gave 97 percent control while the 4.6 and 2.8 pounds actual DDT treatments gave 95 percent control. The

TABLE 3. Number of the larvae of the garden webworm per square yard following insecticide application. Old Horticultural Farm, Manhattan, Kansas. 1947.

Insecticide	Rate in pounds of toxicant per acre	Before treatment	DAYS AFTER TREATMENT: One		Three		Five	
			Number	Percent control	Number	Percent control	Number	Percent control
Check	——	350	349	—	126	—	115	—
DDT 10%	9.1	323	8	98	6	98	0	100
BHC 5% and DDT	2.0 2.0	478	17	96	2	98	0	100
DDT 3%	2.8	360	15	96	7	98	5	96
DDT 5%	4.6	355	25	93	3	98	0	100
BHC 3% gama	2.4	366	68	81	31	75	17	87
BHC 1% gama	0.7	342	159	54	110	13	57	50
Cryolite	32.0	342	249	29	80	37	84	27
Rhothane	3.0	269	224	36	131	0	122	0
Rotenone	10.8	295	256	27	114	10	151	0

TABLE 4. Buffalo alfalfa seed yields in garden webworm control plots and in the plots treated at the first growth and bud stage of development. Fort Hays Experiment Station, Hays, Kansas. 1949.

Treatment	Stage of growth when treated	Average pounds of seed harvested per acre	Percent increase or decrease on check plot
Check (untreated)		806	——
BHC	bud stage	1,073	33
DDT	bud stage	1,050	30
Parathion	bud stage	1,000	24
Aldrin	bud stage	985	22
Dieldrin	bud stage	853	6
Toxaphene	bud stage	642	—20
Chlordane	bud stage	595	—26
Check	untreated	529	——
BHC + DDT	6-8 in. tall	879	66
BHC + DDT	bud stage	872	65
BHC + DDT	6-8 in. tall and bud stage	1,145	116

2.4 pounds gamma BHC gave 80 percent control and 0.7 pounds of BHC gave 45 percent control of the garden webworm. Cryolite, rotenone, rhothane were virtually worthless in controlling the garden webworm. For all practical purposes, the 2.8 pounds DDT to the acre gave complete control of the larvae of the garden webworm and would have given the cheapest control during this experiment on a field basis.

EXPLANATION OF THE ILLUSTRATIONS

All photographs are original and were taken during work at Manhattan by the senior author.

1. Full grown larva of the alfalfa webworm, *Loxostege commixtalis* Walker, from alfalfa. August 27, 1932.
2. Full grown beet webworm, *L. stictacalis* Linn., from lambsquarters, August 27, 1932.
3. Full grown garden webworm to show the segmental markings, *L. similalis* Guen. August 27, 1932.
4. Tops of alfalfa plants webbed together to form the early stage of the so-called "nests" before serious foliage damage has been done. July 9, 1923.
5. Serious foliage damage to young soy-bean plants by garden webworms which migrated from an adjoining alfalfa field. July 3, 1931.
6. Severe foliage injury to the second growth of alfalfa by garden webworms. July 21, 1923.
7. The previous cutting of the portion of the field at the left was made at the normal time, so the new growth received maximum egg deposition and consequently severe foliage damage resulted. The previous cutting of the portion of the field at the right was delayed beyond the normal cutting time, and the new growth was only lightly infested by garden webworm. July 21, 1923.

No garden webworm problem developed in 1948. A few moths of this species were present in the alfalfa fields but the number of larvae produced was not sufficient to warrant an experiment.

An infestation developed on the second cutting seed crop during 1949. The total number of garden webworm larvae taken in five sweeps of an insect net in the untreated alfalfa reached serious numbers. The larvae started webbing the ends of the alfalfa stems at the time of flower bud formation. Their damage to seed production was enormous for those seed-growers that did not have their fields under constant observation. Parathion gave 95 percent control of the infestation. The control was not only high but indications of effectivenes were apparent within six hours of application. Toxaphene also gave 85% control but required 24 hours to become effective while DDT gave 83 percent control but required 36 hours to become effective. Analysis of the data showed the slope of the line for the rate of kill of each of these insecticides to be equal after they became effective.

Hand harvested alfalfa seed samples gave yields of 806 pounds per acre in the check plots, Table 4, compared with 1,073 pounds for the BHC plot. The insecticides also control leafhoppers and plant bugs so that the increase in seed yield should not be credited wholly to garden webworm control. These plots were located within 100 yards of an apiary and this alfalfa was the only alfalfa in bloom at the time. The honeybee colonies numbered five to seven colonies per acre. BHC, DDT, parathion, and aldrin gave the greatest increases in yield. Two of the toxaphene plots developed difficulties associated with moisture. After the experiment was completed, investigations revealed a gravel underlay under parts of the field which, unfortunately, included toxaphene plots in two different blocks.

In an experiment to determine the most practical number of insecticide treatments to apply to alfalfa being left for seed, there were few garden webworms in the plots treated when plant growth was in the bud stage in comparison with the check plots and fewer still in the plots treated when regrowth, following the first cutting reached six inches and at the bud stage of development. Alfalfa seed yields in the garden webworm and DDT and BHC (0.175 γ) spray control plots in 1949 as given in Table 4, shows a 65 percent increase in yield by treating at the bud stage; 66 percent increase in yield when treated at both stages of development.

There were no garden webworm problems in the western half of Kansas in 1950 but there were a few moths present in the alfalfa fields at all times. However, rainfall made the vegetative growth so heavy that the few larvae produced made no inroads on the production. Since the production of a seed crop was impossible under such rainfall conditions the alfalfa was cut for hay at the time of the second or third instars of the garden webworm.

This insect was present in the vicinity of Hays, Kansas in greater numbers during 1951 than in 1949. In 1951 the production of both alfalfa hay and seed was impossible without applying chemical control. To have attempted to obtain a seed crop after allowing the garden webworm to take the second crop would have postponed the seed crop until too late for best yields, Grandfield and Franklin (1952).

In the experiment in 1951 the average number of larvae per 25 sweeps of an insect net before treatment varied from 93.3 to 146.7 (Table 5). The first day after spraying, the average for the check plots was 160.7 larvae per 25 sweeps. Metacide gave 97 percent control of the garden webworm and DDT 95 pecent control 24 hours after treatment. Parathion and toxaphene gave 81 percent and dieldrin 77 percent control. Insecticides which gave good control for the season were: DDT 94 percent, toxaphene 90 percent, dieldrin 89 percent, metacide 88 percent, and parathion 86 percent.

The alfalfa seed yield also reflected the percentages of control of the garden webworm as shown in Table 6. The yields fell into three groups. The best yields were given by methoxychlor, dieldrin, and DDT with 40.8, 39.9, and 38.8 pounds per acre, respectively. On a percentage basis this was an increase of 189, 183, 175 percent, respectively over the yield of the check plots. The second group of insecticides gave yields as follows: chlordane 26.6, toxaphene 25.4, and DDT 24.9 which on a percentage basis was an increase over the check plots of 89, 80, 77 percent, respectively. The third group of insecticides gave yields as follows: aldrin 20.9, metacide 19.3, and parathion and pestox each 17.1 pounds or on a percentage basis an increase of 48, 37, 21 percent, respectively, over the yields of check plots. These low yields resulted from the record rainfall that occurred during July and August which made an alfalfa seed crop impossible. The rainfall and weather conditions also prevented adequate pollination of the flowers which developed.

In an experiment to determine whether one or two applications of insecticide were needed for control, one series of plots was treated with one pound DDT and ¾ pound toxaphene mixture on July 16; a second series of plots was treated July 26; a third series of plots was treated on July 16 and 26, and the fourth series received no treatment. The treatment on July 16 was applied when the alfalfa plant growth had reached 6 to 8 inches in height while the treatment of July 26 was applied at the bud stage of plant growth. There were 11 to 16 garden webworm larvae present in 25 sweeps of a 15-inch insect net on July 16, when the plant growth was only 6 inches in height. In those plots which were treated on this date, 85 to 89 percent control of the garden webworm was obtained, and by the third day, 97 to 99 percent control. These plots which received both treatments had 100 percent control. Control was maintained at the 82 percent level or higher for those plots which received the early treatment only. Good control, 89 percent or higher, was obtained in the plots at the bud stage of plant growth. However, considerable injury had been done by this time.

The seed yield in the untreated plots averaged 41.3 pounds per acre. The plots treated at 6-8 inches in height yielded 69 pounds per acre, the plots treated at the bud stage yielded 78.3 pounds per acre, and the plots treated at both stages of growth yielded 103 pounds per acre. This was an increase of 32 percent over the yield of the plots treated at the bud stage, an increase of 49 percent over the yield of the plots treated when 6-8 inches high and an increase of 149 percent over the yield of the untreated plots.

The outbreak in 1951 was as severe as that reported in 1923. It was larger than the outbreak which occurred in 1934 (Dean and Smith, 1935).

TABLE 5. Number of larvae of the garden webworm obtained per 25 sweeps of a 15 inch insect net in the garden webworm control experiment, buffalo alfalfa field 305, Fort Hays Experiment Station, Hays, Kansas, 1951.

Insecticide treatment	Before treatment July 25	After treatment							Average July 26-August 8
		July 26	July 27	July 28	July 30	Aug. 1	Aug. 4	Aug. 8	
Check	120.3	160.7	125.7	64.7	113.7	75.7	45.7	10.3	85.2
DDT	105.7	7.3	8.7	1.0	3.0	10.0	1.7	1.0	4.7
Percent control	—	95	93	98	97	87	96	90	94
Toxaphene	108.0	30.7	12.3	7.0	2.7	3.3	1.7	1.0	8.4
Percent control	—	81	90	89	98	96	96	90	90
Dieldrin	98.3	37.7	12.7	5.0	3.3	8.0	1.0	0.3	9.7
Percent control	—	77	90	92	97	89	98	97	89
Metacide	146.7	5.0	9.3	14.3	32.6	6.7	2.3	0.3	10.0
Percent control	—	97	93	78	71	91	95	97	88
Parathion	126.0	30.7	9.3	21.0	17.0	5.0	1.0	0.7	12.1
Percent control	—	81	93	68	85	93	98	93	86
Aldrin	140.1	64.0	52.7	24.0	9.3	8.7	4.7	0.3	23.4
Percent control	—	60	58	63	92	89	90	97	73
TEP	130.3	62.0	28.3	32.7	92.3	18.0	11.7	4.0	35.6
Percent control	—	61	77	49	19	76	74	61	58
Methoxychlor	124.3	87.6	65.7	36.3	68.3	15.7	11.3	4.3	41.3
Percent control	—	45	48	44	40	79	75	58	52
Chlordane	93.3	168.0	48.7	41.7	34.3	15.0	5.0	1.7	44.9
Percent control	—	0	61	36	70	80	89	84	47
Pestox	134.3	69.3	68.3	49.7	75.7	35.7	44.7	6.7	50.0
Percent control	—	57	46	23	33	53	2	35	41

TABLE 6. Alfalfa seed yields in the garden webworm control experiment, Buffalo alfalfa field 305, Fort Hays Experiment Station, Hays, Kansas, 1951.

Insecticide	Rate in pounds per acre	Average seed yield in lbs. per acre Average	Percent increase
Check	——	14.1	——
Methoxychlor	2.0	40.8	189.4
Dieldrin	0.5	39.9	183.0
DDT	2.0	38.8	175.2
Chlordane	1.0	26.6	88.7
Toxaphene	1.5	25.4	80.1
TEP	0.5	24.9	76.6
Aldrin	0.5	20.9	48.2
Metacide	0.5	19.3	36.9
Parathion	0.5	17.1	21.3
Pestox	1.0	17.1	21.3

No garden webworm outbreak occurred in Kansas in 1952. Moths were abundant on the third cutting of the alfalfa at Hays, Kansas at the bud stage of plant growth. Estimates of the population averaged 25 moths per square

yard. All of the alfalfa in this field was treated with 1½ pound of toxaphene per acre and no larvae developed.

Summary—This paper summarizes observations on the biology and control of the garden webworm in Kansas by the authors over a period of 32 years. This insect does not overwinter in the latitude of Kansas, but flies in from the south and lays eggs on its favorite host plants. This insect is not present in harmful numbers every year, serious outbreaks having occurred in 1923, 1934, 1949, and 1951.

The first brood larvae appear in the alfalfa field in early May, the second generation early in July, and the third in August. There may be a light brood in September and October. Adults occur at all times during these months and up to killing frost. Eggs are deposited in flat scale like masses containing 1 to 37 glassy or greyish flat circular eggs which contain small pentagonal or hexagonal designs that have enclosed areas which are shiny. As development proceeds they become dull brownish, then smoky-black and quite dark just before hatching. The larvae are active creatures, light to dark greenish-yellow in color, have three pairs of prominent black spots on most of the segments, and a single seta which arises from a small papilla which occurs in each spot. The larvae are gregarious during the first instar stage, then scatter and web the leaves and stems in the top of the alfalfa plant, within which they feed and develop.

When disturbed, the larvae take on a spasm of aimless wriggling. They eat only the epidermis of the underside of the leaves in the early instars, while the later instars consume the entire leaf. When fully grown, the larvae enter the soil and spin coccoons of silk in which they pupate. The pupa is green at first then turning brown gradually until it is a rich yellowish-brown.

No garden webworm outbreaks occurred in Kansas in 1948, 1950, or 1952. This may have been due in part to weather conditions, in part to the timing of the cutting of the alfalfa which may have occurred at an adverse time for the garden webworm. When the garden webworm life cycle and the cycle of the alfalfa cutting are synchronized, damage can occur on every cutting of the alfalfa except the first in eastern Kansas.

The worst outbreak of the garden webworm in Kansas history occurred during 1951. The alfalfa in large areas of Kansas was completely destroyed by the garden webworm on the second and third cuttings. Only those growers of alfalfa that applied insecticides received either a hay or a seed crop.

The best control of the garden webworm was obtained by the use of DDT, toxaphene, dieldrin, metacide, and parathion. Parathion gave the most rapid control while toxaphene and DDT were 24 to 36 hours longer in giving control.

DDT applied at two pounds per acre gave better control and a higher yield of alfalfa seed than did the application of one pound of DDT. Also, the application of insecticides when the alfalfa was only six to eight inches in height and the bud stage of development, gave greater yields than did the application of insecticide at bud stage alone or when the alfalfa had reached six inches in height, or when no application was made. A part of the credit for increased seed yields in the garden webworm experiments is due to the control of leafhoppers and plant bugs by the insecticides.

Under most conditions the use of two pounds of DDT per acre applied when the first webs appear will give the best control. For the protection of the seed crop or on the early plant growth following the removal of a hay crop, this is the Kansas recommendation.

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BRACHYPTEROUS FORM OF *HEBRUS CONSOLIDUS* UHLER (HEMIPTERA, HEBRIDAE)

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Only a single species of the genus *Hebrus* Curtis having both a macropterous and brachypterous form has been described from the Western Hemisphere at the present time. In a recent shipment of Hebridae received from Harold C. Chapman, Entomologist for the Bureau of Entomology and Plant Quarantine, I discovered a series of brachypterous *Hebrus consolidus* Uhler. Drawings and comparison of the two forms with a complete description of the brachypterous specimens follow.

Brachypterous form

Size: Male; length, 1.53 mm. to 1.95 mm.; width across humeri, 0.68 mm. to 0.70 mm. Female; length, 2.00 mm. to 2.55 mm.; width across humeri, 0.69 mm. to 0.73 mm.

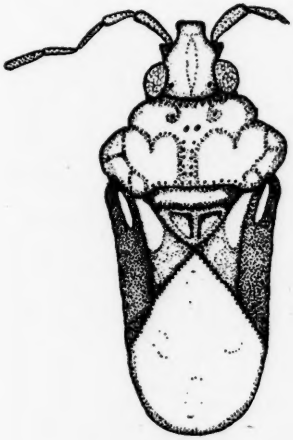
Color: Head fusco-ferruginous, anterior portion of face darker, compound eyes fuscous; antennae testaceous, distal segments darker; pronotum fuscous, nearly concolorous in most specimens; scutellum fuscous, lighter toward apex in some specimens; hemelytra with viens fuscous, median portion lighter, membrane fuliginous, fumose near outer border, pure white area near base; abdomen fuscous, connexivum fusco-testaceous. Underparts: head with buccula testaceo-sulphureous to testaceous, rostrum testaceous; all

sterna fuscous, legs testaceous, darker near joints; abdomen with distal portion of venter fusco-piceous, shiny, except genitalia externa of female and genital capsule of male which are fusco-testaceous.

Structural characteristics: Vertex of head without medial longitudinal sulcus, two anastomosing rows of pits in this area, frons tumid, ocelli normal to reduced in size, antennae similar to macropterous form; pronotum with collar punctate on posterior lateral border, broad shallow medial longitudinal sulcus on disc, two prominent deep pits at anterior end of sulcus and two rows of smaller pits along inner lateral borders of sulcus, humeri reduced and impressed within, row of coarse punctures in depression, punctures continuing near posterior border of pronotum as an acupunctate line, discs demarcated by row of coarse punctures, both discs punctate; scutellum with prominent medial longitudinal carina, rounded at apex, lateral edges upturned; hemelytra greatly reduced, inner vein rounded at inner angle, membrane greatly reduced; abdomen with segments prominent, connexivum turned upward.

Comparison of the two forms: Heads similar except ocelli of brachypterous form may be reduced in size; pronotum of brachypterous form with humeri reduced, pits in sulcus of discs similar in both forms; wings of brachypterous form greatly reduced but shape of veins similar, brachypterous form narrower across humeri than macropterous form.

Data on distribution: Cocoa, Fla., 6 males and 6 females, 28 Nov. 1951, Harold C. Chapman; Mims, Fla., 5 males and 3 females, 17 and 18 Oct., 1951, Harold C. Chapman. Brachypterous forms are known only from Florida.



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CONTENTS OF THIS NUMBER

A Revision of the Nearctic Genera of Elmidae (Coleoptera) (Concluded)
MILTON W. SANDERSON 1

A Genus of Bees New to the Illinois Region
CHARLES D. MICHENER 13

Structural Features of Cochroach Egg Capsules IV. The Oötheca of *Parcoblatta uhleriana.* (Orthoptera: Blattidae)
FRED A. LAWSON 14

Weight Differences in Southwestern Corn Borer Larvae, *Diatraea grandiosella* Dyar, Reared on Teosinte in Kansas in 1952
C. C. BURKHARDT AND REGINALD H. PAINTER 21

Notes on the Species of Drosophilidae (Diptera) Occurring in Kansas
CARL M. YOSHIMOTO 23

The Garden Webworm—*Loxostege similalis* Guen. as an Alfalfa Pest in Kansas
ROGER C. SMITH AND W. W. FRANKLIN 27

Brachypterous Form of *Hebrus consolidus* Uhler (Hemiptera, Hebridae)
T. WAYNE PORTER 38